A rapid assessment technique for mapping ground level CO_2 concentrations using a light-weight, field-rugged gas analyzer

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Figure 1. One of the authors with the LI-8100A configured for ground level CO_2 concentration (GLCC) measurement.

Introduction

- The LI-8100A is a light-weight, field-rugged infrared gas analyzer (IRGA) designed to be used with accumulation chambers to quantify soil CO_2 flux.
- The LI-8100A can be used as a standalone IRGA, without a soil chamber, to sample ambient CO_2 concentrations by taking advantage of its integrated power, data storage and sampling hardware.
- By integrating a global positioning system with the instrument, CO_2 concentration can be rapidly mapped over large spatial scales.
- By combining CO_2 mapping and chamber based flux measurements, the instrument can be used to rapidly screen large areas for potential leaks and measure leak rates at "hot spots" with accuracy.

Mapping ground level CO_2 concentrations (GLCC) in an urban environment (Figures 1 and 2)

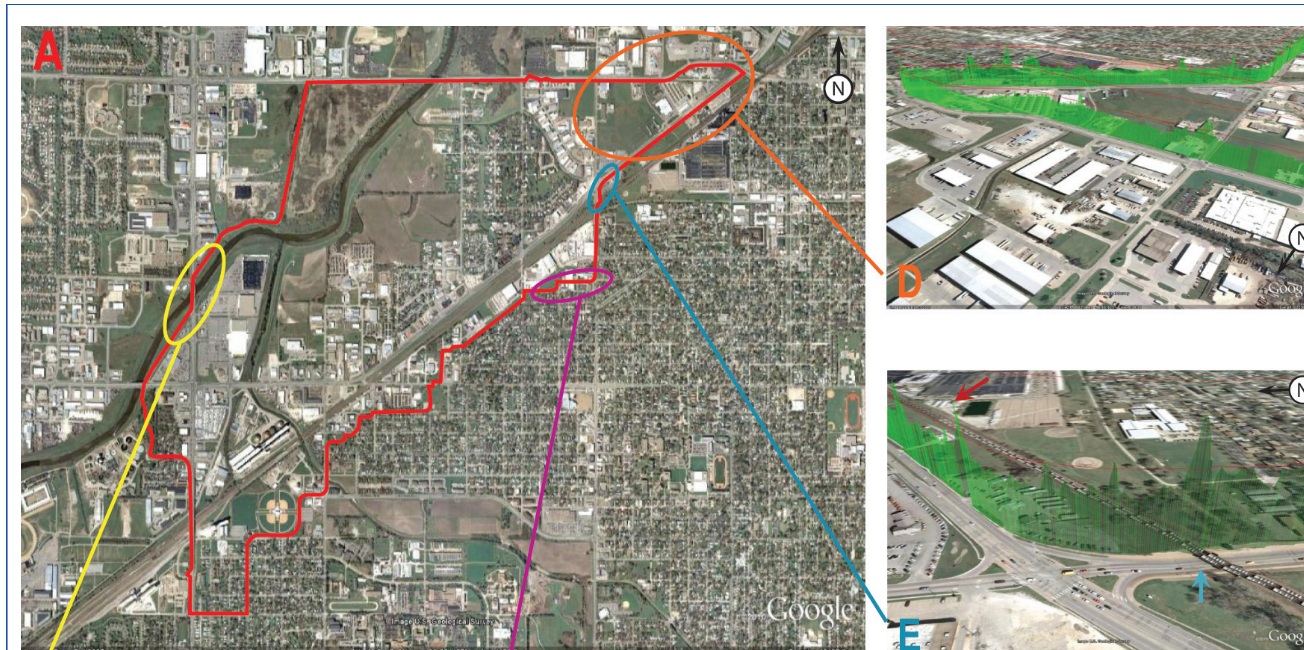
- GLCC was measured along a seven-mile transect in Lincoln, NE, on June 24, 2010.
- During the measurement period, wind speeds were low: <2 m s^{-1}.
- Intake tube height was between 10 and 15 cm above ground level.
- Spatial data paired with CO_2 concentration was imported into Google® Earth as a .kml formatted file.
- The data demonstrates that the measurement technique is sensitive, with changes in GLCC reflecting changes in land cover along the transect.

Combining GLCC mapping and chamber based flux measurements (Figures 3, 4, and 5)

- Measurements of GLCC and soil CO_2 flux were made at the Zero Emissions Research Technology (ZERT) site in Bozeman, MT, during July 19 through 22, 2010.
- See Spangler et al., 2009, for a detailed site description of the ZERT facility.
- A subsurface CO_2 release was performed to generate an artificial "leak" for the testing of various leak monitoring technologies.
- GLCC mapping proved effective in rapidly identifying hot spots of CO_2 release.
- Soil CO_2 flux measurements were able to quantify CO_2 release at the hot spots with a high degree of accuracy (mean r^2 from curve fits of fluxes greater than 100 µmol m^{-2} s^{-1} = 0.997).
- Areas of maximum soil CO_2 flux overlaid areas where the maximum GLCC was measured (Figure 5B).

Conclusions

- GLCC mapping can be used as a rapid assessment tool for identifying aberrations in CO_2 concentration relative to background level.
- Absolute CO_2 concentration measured by GLCC mapping is sensitive to both wind speed and direction, and intake tube height.
- Accumulation chamber based measurements provide a means of directly quantifying fluxes of CO_2 from soil.
- The ability to perform GLCC mapping and chamber based flux measurements with a single instrument designed for field use provides a tool for both leak detection and quantification.



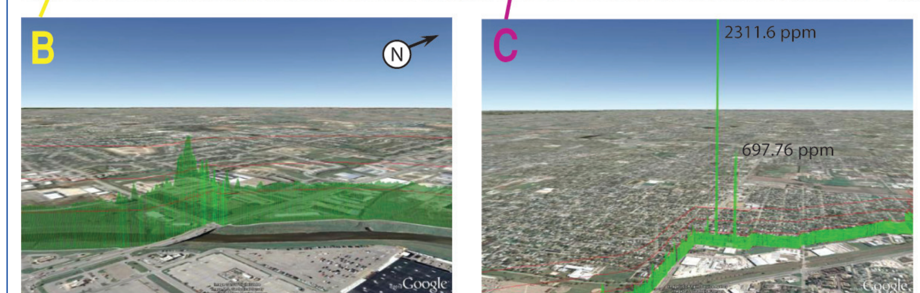


Figure 2. GLCC measured along a seven-mile transect through Lincoln, NE. **Panel A:** Aerial view of the transect (red line). **Panels B, C, D and E:** GLCC mapped at various points along the transect. CO_2 concentrations are adjusted to ground elevation equal to 340 ppm. Floating contours (red) demarcate 400, 450 and 500 ppm relative to ground elevation. **Panel C:** Spikes indicate where the instrument caught exhaust plumes of nearby construction equipment. **Panel E:** Red arrow marks a peak measured when a car turned across the transect. Blue arrow marks a point where the transect and roadway go through an underpass.

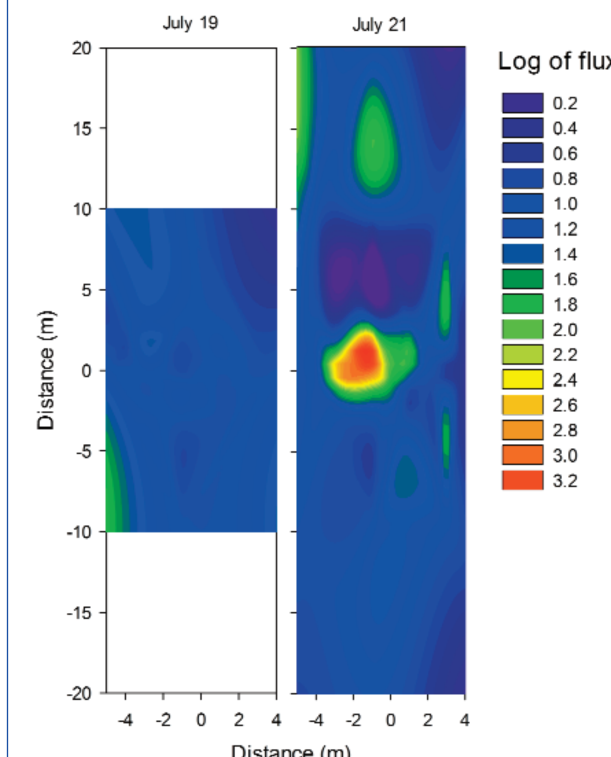


Figure 3. False color images of soil CO_2 fluxes measured at the site on July 19 before the release, and on July 21 during the CO_2 release. The color scale represents the log of the measured flux (Log µmol m^{-2} s^{-1}). On July 19, fluxes ranged from 5 to 15 µmol m^{-2} s^{-1}. On July 21, peak fluxes were around 2000 µmol m^{-2} s^{-1}. The X and Y axes are in meters from the center point of the injection pipe, following the same system as Lewicki et al., 2009.

Figure 4. The LI-8100A configured for accumulation chamber measurements at the ZERT site.

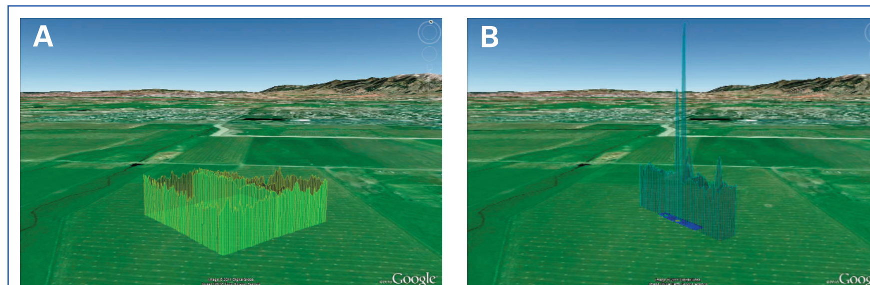


Figure 5. GLCC measured on July 19 pre-release (panel A) and on July 22 during the CO_2 release (panel B). CO_2 concentrations are adjusted to ground elevation equal to 360 ppm. In panel B, the false color image of soil CO_2 flux from Figure 3 has been overlaid to show the agreement between spikes in GLCC (maximum of 506 ppm) and peak soil flux measurements. A reduced transect is shown in panel B to better illustrate the agreement. The path around the outside of the plot (as shown in panel A) yielded GLCC near ambient (mean 392.12 ppm, st. dev. 5.04 ppm).

References

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